Amphibians of the Gibraltar Range

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The Gibraltar Range supports a relatively high diversity of amphibians and thirty frog species, with equal numbers of tree frogs (Hylidae) and ground frogs (Myobatrachidae) having been recorded there. It is postulated that the geological history of the Great Dividing Range and the rugged landforms on its eastern edge, known as the Great Escarpment, provides the underlying explanation for the amphibian diversity present. Among the amphibians four major biogeography groups are recognized based on distribution and association with major vegetation communities. The largest group consists of 15 species that have wide distributions within and beyond the range and occur in several vegetation communities, and only one member is categorized as threatened. The second group consists of 12 species and is associated with wet forest habitats of the escarpment and coastal belt, with four threatened species. The third group is restricted to rainforest habitats and consists of three species of ground frog, two of which are threatened. The final group is associated with the drier open forests and grasslands of the tablelands and western slopes and consists of four species, three of which are threatened. No frog is endemic to the range, although one ground frog, *Philoria pughi*, is found only in the range and the nearby New England Range and Timbarra Plateau. This species and *Assa darlingtoni*, another ground frog, are closely associated with the warm temperate rainforest that is restricted to the higher altitudes on the Gibraltar Range, and their distribution is considered to be relictual. Their broader distribution is within isolated montane rainforest that occurs on the higher peaks of the Great Escarpment and coastal ranges. Among the frogs of the Gibraltar Range, 11 of the 30 species are categorized as threatened, eight of which are associated with stream habitats. This is despite the large areas of undisturbed natural habitat present on the range. In contrast species associated with pond habitats are less represented in this group.

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INTRODUCTION

An investigation of the biogeography of the amphibian fauna of the Gibraltar Range in northeast New South Wales was undertaken to shed light on their origins, relationships and the implications of these for conservation management. The study of biogeography is fundamentally concerned with the documentation and interpretation of the distribution of flora and fauna and their interrelationship. Uncovering origins and dispersal routes of organisms largely depends upon the degree of resolution of distributional data and robust phylogenetic reconstructions of evolutionary relationships (Tyler et al. 1974).

An understanding of the composition and ancestry of the amphibian fauna of the Gibraltar Range is underpinned by interpretations of the geological history of the landforms of the range and its climate. The Gibraltar Range occurs on the eastern boundary of the Great Dividing Range. The Great Dividing Range is the dominant landform feature of the east coast of Australia, and running along its eastern edge is the Great Escarpment. Ollier (1982) postulated that the escarpment originated by scarp retreat from a new continental edge of eastern Australia about 80 million years ago. From a biogeographic perspective this results in two principle axes; the first is in the north-south direction of the Great Divide and the associated Great Escarpment that extends in the order of hundreds of kilometres, the second is in the east-west direction from coast to tablelands that extends in the tens of kilometres.

The geologic history of the Gibraltar Range and its landforms are significant factors in our understanding of the composition and ancestry of the amphibian fauna. The higher mountains on the Great Escarpment

experience a climate of moderate temperatures and high rainfall and support mesic forest vegetation communities at mid to high altitudes. These forests contain ancestral elements of wet forest communities that were once more widespread, particularly along the Great Divide, and have contracted as the Australian climate has dried (Nix 1991).

In the north-south axis the higher mountains along the Great Divide provide refuges for the flora and fauna adapted to these mesic habitats and provide a view of their evolutionary history. The frog species found in the mesic forest habitats are postulated to reflect a long evolutionary relationship between the flora and fauna. In the north–south axis the Gibraltar Range is one of many ranges that form the relatively continuous Great Divide. While it may be relatively continuous as a major landform feature it has considerable variation in altitude and ruggedness along its considerable length. The Gibraltar Range is one of the higher ranges along the length of the Great Divide with its highest peaks being above 1400 metres in altitude, and along with a rugged topography and complex underlying geology (Barnes et al. 1995) result in a complex mosaic distribution of rainforests and wet sclerophyll forests.

In the east-west axis the Gibraltar Range stands at the junction of two major geomorphic provinces, the tablelands to the west and the coastal belt to the east. In this axis the formation of the Great Escarpment and the mountain ranges, river valleys and coastal plains associated with it, provide a diverse topography from low to high altitude. On its western side the Gibraltar Range has upland areas of low relief with gently flowing streams and tableland swamps. On the east is a steep escarpment with rapidly flowing streams and deep gorges, and to the northeast is an area of moderate to high relief with rapid flowing streams. To the south and east the scarp is clearly defined by the Mann River and its smaller tributaries, while to the northeast the range is almost cut off by the Rocky (Timbarra) River to form an isolated plateau. This river runs in a northerly direction along the line of Demon Fault that separates the Gibraltar Range from the tablelands to the west.

While the Gondwanan origin and relationship of Australia's two major frog families, the Hylidae (tree frogs) and Myobatrachidae (ground frogs) is well accepted, the geographic context of the evolution and diversification of the Australian frog fauna remains a matter of considerable debate (Tyler 1979; Roberts 1998). Two major features of their evolution can be investigated by studies of the fauna of the Great Divide. The first is evidence of the ancestral composition of the amphibian fauna of the mesic forests that have been associated with the Great Divide for tens of millions of years, and the second is the extent of diversification that has occurred as the Great Divide has been eroded away and as climate has changed.

The objective of this paper is to provide an overview of the diversity of frogs in the major vegetation communities of the Gibraltar Range along with an interpretation of the composition and ancestry of the amphibian fauna. Where appropriate, details of habitat use and conservation status will be discussed along with the implications for management.

MATERIALS AND METHODS

To compile a list of the amphibian species of the Gibraltar Range a number of sources were consulted. A primary species list was assembled by consulting the records of the Australian Museum, Queensland Museum, Victorian Museum and South Australian Museum. To these were added the records in the Wildlife Atlas of New South Wales (NSW DEC, NPWS, accessed April 2005). A selected literature search was conducted that included large and comprehensive surveys such as the North East Forest Biodiversity Survey (NSW NPWS 1994) and Fauna Surveys for Forestry Environmental Impact Statements (Smith et al. 1994; State Forest NSW, 1995). Lastly, records from targeted surveys for taxonomic studies and from a long-term monitoring site in Washpool National Park were included (Knowles et al. 2004; Donnellan et al. 2002, 2004; Mahony unpubl. data). In addition, information on the vegetation communities and habitats occupied by each species was collated.

Based on distribution records and association with major vegetation communities frog species were assigned to one of four categories, 1) widespread occurrence across the region in all major vegetation communities, 2) eucalypt-dominated forest communities of the escarpment and coast belt, 3) rainforest specialists, and 4) woodlands, dry forests and grasslands of the tablelands. Within these categories the frogs were subdivided on the basis of primary breeding habitat.

Conservation status of species was based on listings in the New South Wales *Threatened Species Conservation Act* 1995 (NSW TSC Act 1995) supported by a recent assessment of Australian amphibians that applied the International Union for the Conservation of Nature (IUCN) categories (Global Amphibian Assessment 2004).

RESULTS

A total of 30 frog species has been recorded from the Gibraltar Range and a further four are considered likely to occur there (Table 1). Equal numbers of tree frogs (Hylidae) and ground frogs (Myobatrachidae) are found. All hylids present are members of the genus *Litoria,* while there are eight genera of myobatrachids. Despite the relatively high species diversity many species are represented by a small number of location records, and for several species by a single location record. As a result the regional distribution, abundance and habitat associations of many species are incomplete. Fauna surveys conducted for the North East Forest Biodiversity Study (NSW NPWS 1994) and Forestry EISs (SF NSW 1995) provide the most detailed picture of the distribution and abundance of species. Discoveries made during surveys in the last two decades indicate that significant distributional records, and even new species, may be found there (Donnellan et al. 2002; Knowles et al. 2004).

Frogs with a widespread distribution

Division of the frog fauna into major distribution patterns and broad vegetation community associations reveals that the largest group numerically is species that have a widespread distribution and that occur in several vegetation communities. Fifteen species are placed in this group, seven tree frogs and eight ground frogs (Table 1). Most of these frogs have extensive distributions in south-eastern Australia (see distribution maps in Cogger 2002 and Robinson 2002). This is not to say that they are necessarily habitat generalists. Subdivision of these species by preferred breeding habitat shows that the majority, 14 of the 15, make use of ponds or swamps, four use both ponds and streams and could be considered to be generalists in respect of breeding habitat, and only one is a stream specialist. Two species that use ponds show a preference for ephemeral ponds and a third (*Crinia signifera*) makes use of a wide range of water bodies from small ephemeral pools to large swamps, indeed the only habitat it is not found in is fast flowing streams. This species occurs in disturbed sites and therefore is common where human activity opens or modifies habitats.

Only one species in this group is categorized as threatened. The New England Tableland population of *Adelotus brevis* is listed as an "endangered population" under the *NSW TSC Act*. No recent records of this species were found at high altitudes in the Gibraltar Range, but several populations are known from lower altitude in Washpool National Park (NP) and Ewingar State Forest (SF).

Frogs of forest communities of the escarpment and coastal belt

The second largest group is associated with eucalypt-dominated forest vegetation communities of the escarpment and coastal belt. Twelve species are placed in this group, eight tree frogs and four ground frogs (Table 1). As might be expected due to the rugged topography of the escarpment the majority of these species are associated with stream habitats. Six species, three tree frogs and three ground frogs, breed in streams and have tadpoles adapted to stream habitats. Among these, three species, *Litoria subglandulosa, L. piperata* and *Mixophyes balbus*(Fig. 1b), are restricted to higher altitudes on the escarpment. Vegetation community is not the major factor determining their distribution; they occur in streams within heath, dry forest, wet forest and rainforest communities. One stream frog, *Mixophyes iteratus* (Fig. 1c), is found only at low to moderate altitudes and is always associated with rainforest or wet forest habitats. The remaining two species (*L. barringtonensis* and *M. fasciolatus*) occur across the range of altitudes but always in wet forest communities.

Five species in this group breed in ponds and swamps, and two of these often breed in ephemeral situations (Table 1). For three of the species included in this group (*L. brevipalmata, L. revelata* and *L. tyleri*) there are no confirmed records in the Gibraltar Range. They are included here because they occur in wet forest habitats to the north, south and east of the Gibraltar Range and it is considered possible that they occur in the range. If these species do occur they are not abundant because they have not been detected in systematic surveys (NSW NPWS 1994; Smith et al. 1994; State Forests NSW 1995) or targeted searches (Mahony unpubl.). *Litoria brevipalmata* is often difficult to detect in field surveys because adults are active at breeding sites on only one or two evenings of the year. Records of *L. revelata* may be absent for a different reason. This species was overlooked in the past and until recently it was not distinguished from *Litoria verreauxi,* a close relative. Field guides do not indicate that *L. revelata* is found south of the Border Ranges region, which are approximately 120 kilometres to the north-east of the Gibraltar Ranges, yet recent field studies (Price 2004) indicate that it occurs in a series of apparently isolated populations along the escarpment and coastal ranges as far south as the Sydney Basin. Targeted searches for this species have been conducted in the Washpool National Park

Association with major vegetation community Species scientific and common name		Conservation status	Typical breeding location			
			Stream breeding (lentic)	Pond and/or swamp breeding (lotic)	Ephemeral pool breeding	Terrestrial eggs and embryonic stage.
Widespread occurring in many vegetation communities from rainforest to grassland						
Litoria caerulea	Green Tree Frog			X		
L. dentata	Bleating Tree Frog			X	X	
L. fallax	Dwarf Tree Frog			X		
L. latopalmata	Broad-palmed Frog			X		
L. peronii	Peron's Tree Frog			X		
L. verreauxi	Whistling Tree Frog			X		
L. wilcoxi	Rocky River Frog		X			
Adelotus brevis	Tusked Frog	EP	X	X		
Crinia signifera	Eastern Froglet		X	X	X	
Limnodynastes dumerillii	Banjo Frog		X	X		
L. ornatus	Ornate Burrowing Frog		X	X	X	
L. peronii	Striped Marsh Frog			X		
L. tasmaniensis	Spotted Grass Frog			X	X	
Uperoleia fusca	Dusky Toadlet			X		
U. laevigata	Smooth Toadlet			X		
Escarpment and coastal belt. Wet forests excluding rainforest specialists						
Litoria barringtonensis	Barrington Tree Frog		X			
*L. brevipalmata**	Green-thighed Frog	V		X	X	
L. chloris	Red-eyed Frog			X	X	
L. gracilenta	Dainty Tree Frog			X		
L. piperata	Peppered Frog	E	X			
*L. revelata**	Revealed Frog			X		
L. subglandulosa	Glandular Tree Frog	V	X			
*L. tyleri**	Tyler's Tree Frog			X		
Mixophyes balbus	Stuttering Frog	E	X			
M. fasciolatus	Great Barred Frog		X			
M. iteratus	Giant Barred River Frog	E	X			
Pseudophryne coriacae	Red-backed Toadlet					X
Restricted to high altitude. Rainforest specialists						
Assa darlingtoni	Hip-pocket Frog	V				X
Lechriodus fletecheri	Sandpaper Frog				X	
Philoria pughi	Mountain Mist Frog	V				X
Tablelands and western species. Woodlands, dry forest and grasslands						
Litoria booroolongensis	Booroolong Frog	E	X	X		
*L. castanea**	Yellow-spotted Bell Frog	E	X			
Crinia parinsignifera	Beeping Froglet			X		
Pseudophryne bibroni	Brown Toadlet	EP		X		X
Total			13	21	6	4

without success. The final species, *L. tyleri,* is readily distinguished and the lack of records may indicate that it does not occur in the Gibraltar Range.

Five species in this group are classed as threatened, and each of these breed in stream habitats. In contrast, no pond-breeding species in this grouping is threatened. One of the two stream-breeding species that is not threatened, *Mixophyes fasciolatus*, breeds in both ponds and streams.

Frogs that are found only in rainforest habitats

The group with the narrowest distribution is the rainforest specialists, with only three species, all of which are ground frogs. The absence of tree frogs from this group is not unexpected, given that there is no tree frog that is restricted to rainforest vegetation communities of the Great Escarpment in NSW and south-east Queensland. It is not until the rainforests of far north Queensland that we encounter tree frogs that are restricted to rainforest habitats.

Two of the ground frogs, *Assa darlingtoni* (Fig. 1a) and *Philoria pughi* (Fig. 1d) reflect refugial distributions. They occur only at higher altitudes in warm temperate rainforest or deeper gullies with subtropical rainforest. In the Gibraltar Range the distribution of *Assa* is limited to a relatively small area of high altitude warm temperate rainforest (above 1000 m) and *Philoria pughi* has a slightly wider distribution in warm temperate and subtropical rainforest from mid to high altitudes (800 to 1000 m). These vegetation communities are relicts of former more widespread vegetation communities. They attest to a past when the climate was wetter and milder and when their distribution was more continuous along the great escarpment. The last member of this group, *Lechriodus fletcheri*, is found in rainforest from low to high altitude and thus its distribution is more extensive.

Table 1. LEFT

Major habitat association, breeding location and conservation status of the frogs of the Gibraltar Range. Conservation status is based on IUCN categories (Stuart et al. 2004). For a small number of species there are no records for the Gibraltar Range; they are included because populations are known in forested habitats to the north, south and east and it is likely that they occur in the Gibraltar Range. They are identified by an asterisk. An ephemeral water body is defined as a non-perennial; it can be a pool that lasts for a matter of days or weeks or up to several months.

Frogs of the woodlands, dry forests and grasslands of the tablelands

Another relatively small group are the frogs that are associated with the vegetation communities of the tablelands and western slopes. Four species, two tree frogs (*Litoria booroolongensis* and *L. castanea*) and two ground frogs (*Crinia parinsignifera* and *Pseudophyrne bibroni*) are placed in this group (Table 1). The group may be even smaller because there is no direct evidence that the two tree frogs (*Litoria booroolongensis* and *L. castanea*) occur in the Gibraltar Range. They are included here because of proximity of records on the tablelands and the presence of suitable habitat in the range. Both species have disappeared from the New England Tableland (Hines et. al. 1999; Mahony 1999) and it may be that we will never know whether they occurred on the Gibraltar Range. *Litoria boorolongensis* had an extensive distribution on the New England Tableland and on the western slopes south to the Australian Alps, and suitable habitat in the Gibraltar Range occurs along the upper reaches of the Mann River and Rocky (Timbarra) River. *Litoria castanea* had a far narrower distribution that was centred on tableland habitats. Its preferred habitat was tableland swamps and lagoons and the upper altitudes in the southern areas of the Gibraltar Range contain significant tableland swamps in undisturbed condition.

Of the two ground frogs in this group, one, *P. bibroni,* has also disappeared from the tablelands (Mahony unpubl. data). There are no records of this species from the Gibraltar Range, but once again its was formerly widespread across the tablelands (Heatwole et al. 1995). The remaining species in this group, *C. parinsignifera,* is common and widespread being found in ponds and swamps in open vegetation communities, and is often associated with disturbed areas. The limit of the distribution of the two tree frogs (*L. booroolongensis* and *L. castanea*) is at the upper or western edge of the escarpment on the other hand the two ground frogs are also distributed to the east on the coastal plain, but they are not found in the wet forest habitats of the escarpment. *Pseudophyrne bibroni* is replaced by a congener *P. coriacae* in the wet forests of the escarpment, and *C. parinsignifera* shows a preference for open habitats.

Each member of this group has a distinct breeding biology and behaviour and there is no apparent link between these features and those that have disappeared. *Litoria booroolongensis* breeds in flowing streams, *L. castanea* in swamps and pools, sometimes in large still pools on streams, and *P. bibroni* lays its eggs in terrestrial sites near swamps and pools.

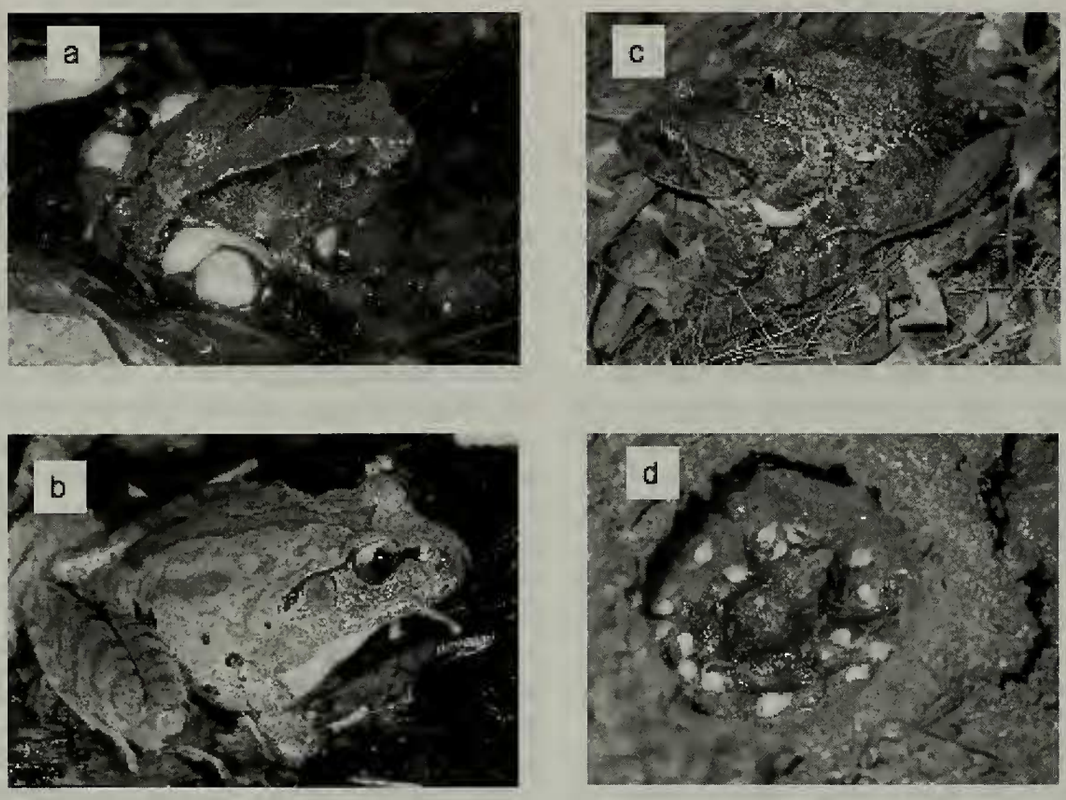

Figure 1. a) Adult male *Assa darlingtoni* surrounded by hatching embryos prior to their entering into his lateral pouches where they will undergo the tadpole stage of their life cycle. This terrestrial frog is found only in warm temperate rainforests at high altitude in the Gibraltar Range. b) Adult male *Mixophyes balbus*, an endangered stream-breeding species that occurs in high altitude streams of the Gibraltar Range. c) A pair of *Mixophyes iteratus* in embrace prior to egg deposition. This vulnerable species is found in stream habitats at low altitude in the Gibraltar Range. d) A male *Philoria pughi* within its terrestrial nest chamber that has been exposed by lifting away a covering of leaves. A clutch of embryos in early stages of development and still within their egg capsules can be seen beneath the male. After the embryos hatch, the tadpoles remain in the nest and leave after metamorphosis.

No frog species is endemic to the Gibraltar Range. *Philoria pughi* has the narrowest distribution, it is known only from the Gibraltar Range, and the New England Range and Timbarra Plateau to the north. Two others, *Assa darlingtoni* and *Lechriodus fletcheri*, occupy refugial mesic forest habitats, and their populations in the Gibraltar Range are isolated from other restricted populations along the Great Escarpment.

DISCUSSION

The high diversity of amphibians found in the Gibraltar Range can be explained by a combination of factors; the antiquity of the Great Dividing Range, the abrupt change in altitude and the rugged landscape of the Great Escarpment, and the consequent climate differences. The range stands at the junction of two ancient geomorphic regions, the tablelands to the west and the coastal plain to the east, and provides habitats for species that have evolved in these regions. These differences are reflected in the aquatic habitats that are present, from tableland swamps with slow flowing streams to fast flowing streams on the escarpment. The rugged topography of the region, its altitudinal range and climate result in the presence of several major vegetation communities.

All of the frogs found on the Gibraltar Range belong to two families that have a long evolutionary relationship with the Australian continent; the tree frogs of the family Hylidae and the ground frogs of the family Myobatrachidae. These families are recognized as being of Gondwana origin (Tyler 1979); they are old endemics. Molecular genetic evidence indicates that the ancestral tree and ground frogs were already well differentiated at the time Australia separated from Antarctica some 52 million

years ago (Daugherty and Maxson 1982; Hutchinson and Maxson 1988). Apart from the introduced cane toad (family Bufonidae) Australia has members of two other families of frog, the Michrohylidae and Ranidae. Members of these families are considered to have arrived in Australia in more recent geological time, when the Australian continent came into closer contact with south-east Asia (Tyler 1979), and their members are found only in rainforest habitats in north Queensland and the Northern Territory.

Several genera and species groups that have a long association with the mesic forest habitats of the Great Divide and escarpment can be identified in the Gibraltar Range. Two examples are briefly considered, one from each of the major families, to illustrate this point. The five species of *Mixophyes* are found only in wet forest habitats along the Great Divide and escarpment from east Gippsland in Victoria to the Atherton Tablelands in far north Queensland, with a further species found in montane rainforest in Papua New Guinea (Donnellan et al. 1990). Phylogenetic studies (Heyer and Leim 1996; Kluge and Farris 1976) place this genus in a basal position among the myobatrachids and their current distribution and habitat preferences strongly suggest they have had a long association with the wet forests of the Great Divide and escarpment. Among the tree frogs members of the *Litoria citropa* species group (Tyler and Davies 1978) are closely associated with the wet forests of the Great Divide and escarpment from southern Victoria to mid east Queensland (Donnellan et al. 1999; Mahony et al. 2000).

A detailed account of the frogs of the New England Tablelands region, an area about nine times larger in extent than the Gibraltar Range, was presented by Heatwole et al. (1995). The Gibraltar Range is adjacent to the north-east of this region and the western portion of the range was included in their investigation. They reported 46 species in the New England region and concluded that the largest numbers were associated with moist habitats that are distributed along the east coast and onto the Great Dividing Range. They did not have extensive data from the Gibraltar Range region and inspection of their data reveals that most of their records were from along the Gwydir Highway, which cuts east-west across the range, and a small number of sites in the Gibraltar Range National Park. Nonetheless, the current study provides strong support for their major conclusion. The 30 species present in the Gibraltar Range account for 65% of the total number they reported for the larger region. It is evident that the mesic habitats of the Great Escarpment and coastal belt provide a diversity of habitats and this is reflected in the number of amphibians present.

The significance of the geomorphic processes that have shaped the Great Escarpment in relation to the evolution of its terrestrial fauna is evident in the Gibraltar Range. With respect to the north-south axis the Gibraltar Range is an isolated area of uplands. Scarp retreat created firstly steep gorges and then wider valleys, as these valleys widened and their headwaters retreated further west the higher altitude ranges of the Great Divide and their fauna and flora were isolated (Ollier 1982). It is postulated that dispersal was limited where large valleys with drier vegetation communities dissected the ranges. For example, in the Gibraltar Range isolated populations of a small number of rainforest frogs are found at higher altitudes (*Assa darlingtoni, Philoria pughi,* and *Lechriodus fletcheri*) in mesic rainforest communities. In addition to the isolation resulting from landscape barriers are the barriers that were created as climate changed. In the past the climate was warmer and wetter and the mesic vegetation more widespread on the Great Divide (Nix 1991), providing an opportunity for species adapted to the mesic forest habitats to disperse. From the perspective of the amphibian fauna the period or extent of isolation of the Gibraltar Range has not been extensive because only one frog, *Philoria pughi* can be described as endemic to the Gibraltar and the nearby New England Ranges.

From the perspective of the evolution of its amphibian fauna it is perhaps more appropriate to view the Gibraltar Range as part of a larger unit of the eastern escarpment of the New England Tableland, which extends from the Macleay River incursion in the south to the Clarence River incursion in the north. Two species associated with the fast-flowing streams of the upper escarpment, *L. piperata* and *L. subglandulosa,* are found only within this region. *Litoria daviesae*, a sibling species of *L. subglandulosa,* occurs to the south of the Macleay River catchment, and *L. pearsoniana,* a sibling of *L. piperata,* occurs in the mesic forests on the northern side of the Clarence catchment. Among the ground frogs, *M. balbus* reaches the extent of its distribution at the northern incursion of the Clarence River, and to the north a sibling species, *M. fleayi,* occurs in mesic forest habitats. A similar pattern occurs within *Philoria*, to the north of the incursion of the Clarence River *P. pughi* is replaced by *P. kundagungan,* and to the northeast by *P. loveridgei* and *P. richmondensis* (Knowles et al. 2004). This genus more than any other is indicative of the isolation of mesic forest habitats in north-eastern New South Wales in the past 15 million years (Knowles et al. 2004).

Despite the protection of large portions of the Gibraltar Range in conservation reserves a considerable number of the frogs found there are classified as threatened. Nine of the 30 species are categorized as either endangered or vulnerable. In the case of those species found in isolated rainforest remnants the categorization is related to small population size and limited distribution, and the potential factors threatening their short-term survival are associated with habitat loss, changes in hydrology and pollution. In the long-term their evolutionary potential may be impacted by climate change. A similar explanation is not possible for those threatened species that are found in vegetation communities that are more widespread or those not limited to specific vegetation communities.

Most threatened are frogs that breed in streams and are associated with stream habitats, they include *L. piperata, L. subglandulosa, M. balbus* and *M. iteratus*. There is extensive habitat for these species in the Gibraltar Range and in the wider region. It is difficult to argue that declines in abundance and the disappearance of their populations are due primarily to habitat loss or degradation. Undoubtedly, habitat modification, particularly on the tablelands where there is a long history of agricultural activity may have impacted on species such as *L. booroolongensis*, but this explanation is not tenable across the wider distributions of these species. It is most likely that the cause of declines is due to the impact of an invasive pathogenic fungus that causes the disease chytridiomycosis in frogs (Berger et al. 1998, 2004). High altitude stream frogs are known to be most susceptible to this disease (Berger et al. 2004) and the threat to their long-term persistence remains in the balance.

One species of conservation significance, the peppered frog (*L. piperata*), deserves more detailed consideration. This frog was described in 1985 from a small number of high altitude locations distributed on the edge of the Great Escarpment in the New England region, extending from the Oxley River Gorge (Gara River) in the south to several sites on the headwaters of the Clarence River in the north (Mann, Oban, Henry and Sara Rivers; Tyler and Davies 1985). All specimens, with the exception of two collected at the Gara River in 1952, were collected in the early 1970s. Several specimens were obtained from Diehard Creek, which drains south-west from the Gibraltar Range to the Mann River. Conservation assessments of the peppered frog have been fraught with difficulty. No specimens of this or other members of its species group (*Litoria citropa* species group, Tyler and Davies 1978; Donnellan et al. 1999) were detected during intensive searches conducted in the 1990s at any of the locations named in the species' description (NSW NPWS 1994; SF NSW 1995). Searches were extended to likely habitats within the region and small "peppered" tree frogs were found at Rockadooie and Seven Mile Creeks in the catchment of the Rocky (Timbarra) River in the north-west region of the Gibraltar Range, and at Cooraldooral Creek, a catchment of the Mann River, in the south-west region in Gibraltar Range. Other populations were detected on the Timbarra Plateau (Nelsons Creek) to the north of the Gibraltar Range.

Genetic comparisons of the "peppered" frogs from each of these sites with a larger collection of specimens of members of the *Litoria citropa* species group from across the Great Escarpment and coastal belt placed these specimens within the species recognized as the Barrington Tree Frog (*Litoria barringtonesis*; Donnellan et al. 1999). Such a result would normally lead to a questioning of the taxonomic status of the Peppered Frog. However, because no specimens could be collected from any of the historical sites listed in the species' description, and suitable genetic material could not be extracted from the fixed museum specimens to be included in appropriate genetic comparisons, the question remains open. Furthermore, the type series of *L. piperata*, which consists of over 70 specimens, has been closely examined, and there is general agreement among herpetologists that *L. piperata* is distinctly different from *L. barringtonensis*.

The Peppered Frog is listed as endangered and a Recovery Plan has been prepared (NSW NPWS 2001). If we accept the position that it is morphologically distinct, then there is no evidence of an extant population and the species should be considered as presumed extinct. Whatever the situation, the Gibraltar Range provides important high altitude plateau and escarpment streams considered to be the habitat of this frog.

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